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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Region 8
Albuquerque, New Mexico

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OBSERVATION OF PLANT COMPETITION, PLANT SUCCESSION,
PLANT-SOIL RELATIONSHIPS, OVERGRAZING AND EROSION
ON SAGEBRUSH AREAS

SUGGESTED EROSION CONTROL METHODS AND TECHNIQUES

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INTRODUCTION

The material presented in this booklet is based upon root excavations; studies of soil profiles; field observations; results of methods employed by various work agencies and land operators; S. C. S. field personnel, and other state and federal technical personnel, and a survey of the literature. The recommendations based upon the above sources are being released to the personnel of Region 8 because of the critical erosion problems in many of the sagebrush areas. By no means are they to be considered complete or final, but as a guiding basis upon which to formulate practices and stimulate thought in the field for further evaluation. It is the earnest desire of the writers that this material will aid in the development of practical and economic methods of soil and water conservation on sagebrush areas. Careful observation and investigation of plant succession as related to plant-soil relationships, and regulated grazing, in connection with different sagebrush control methods and soil and water conservation techniques will ultimately indicate certain particular successful means of treatment for each particular soil type and habitat.

Final development of effective methods and techniques will be hastened by suggestions, findings and ideas of field personnel that are transmitted to the writers in order that they may be compiled, evaluated and made available to workers in other projects.

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SUGGESTED EROSION CONTROL METHODS AND TECHNIQUES

Big sagebrush (*Artemesia tridentata*) is a profusely branched woody perennial 2 to 12 feet high. The herbaceous young stems are grayish-white and the older ones dark brown or black with three-lobed silvery-green leaves. This species is not as palatable as many browse plants, but many stockmen depend on it to carry their stock through periods of drought and heavy snows. It is probably the most abundant shrub in the western states. It ranges in distribution from altitudes of 3,000 feet in Oregon to 10,500 feet in the Wasatch Mountains of central Utah. It was naturally predominant in regions having an annual precipitation between 5 and 10 inches, most of which came in the winter months, but with the elimination of grass competition by overgrazing it has extended its dominance into areas exceeding 20 inches of rainfall (16).* In the latter areas grasses again assume dominance when grazing is restricted or eliminated. At least three-fourths of the entire area now dominated by sagebrush was formerly a grass-sagebrush savannah.**

Sagebrush at present is the dominant species in three distinctive habitats:

1 - Sagebrush areas are referred to in ecological literature as "The Northern Desert Shrub Formation." This habitat has an annual precipitation between 5 and 10 inches. The rainfall is lowest

*Numbers in parenthesis refer to references noted in the Bibliography.

**Savannah - A large grassy area covered in part with scattered trees and shrubs.

in summer and the heaviest precipitation occurs as show during three or four winter months. Under this low precipitation a grass cover is maintained with difficulty, and then only when most of the moisture comes during the growing season. It is probable, therefore, that there has never been any appreciable amount of grass associated with sagebrush in regions with this amount and seasonal distribution of rainfall. Sagebrush occurring under these conditions will not be treated further in this paper as it is evident erosion control measures cannot result in the widespread establishment or encouragement of more effective erosion control species. Up to this time very little of this type lies within Region 8 Soil Conservation Projects or CCC camp areas. Sagebrush was also originally the dominant vegetative cover on areas of varying extent within the grassland-sagebrush savannahs. It dominated the deeper immaturely developed soils not suitable for maintaining grass stands. Since sagebrush now occurs in about the same density and vigor over both the former sagebrush and grassland areas, it is essential that careful consideration be given the plant-soil relationships in each area before any artificial treatment designed to establish a grass cover is initiated. Such work will have a reasonable chance of success on areas where the soil formerly supported a grassland-sagebrush savannah. Where the soil is such that it has never supported other than a cover of sagebrush, efforts to establish a grass cover are virtually wasted.

2 - Sagebrush occurring in annual rainfall belts of 10 to 18 inches was formerly a grama-galleta-sagebrush savannah on the moderately mature and maturely developed soils.

The major portion of sageland within S. C. S. work areas of Region 8 falls within this classification. Discussion will, therefore, largely be confined to a consideration of problems within this plant association.

3 - Sagebrush occurring in annual rainfall belts of over 18 inches was formerly a bunch grass sagebrush savannah. This area is the southeastern extension of the Palouse grass formation and occurs in this region only in northern Utah.

GRAMA GALLETA SAGEBRUSH SAVANNAH

Sagebrush areas occurring in rainfall belts between 10 to 18 inches were originally characterized by a grama-galleta-sagebrush savannah. (Fig. 1).

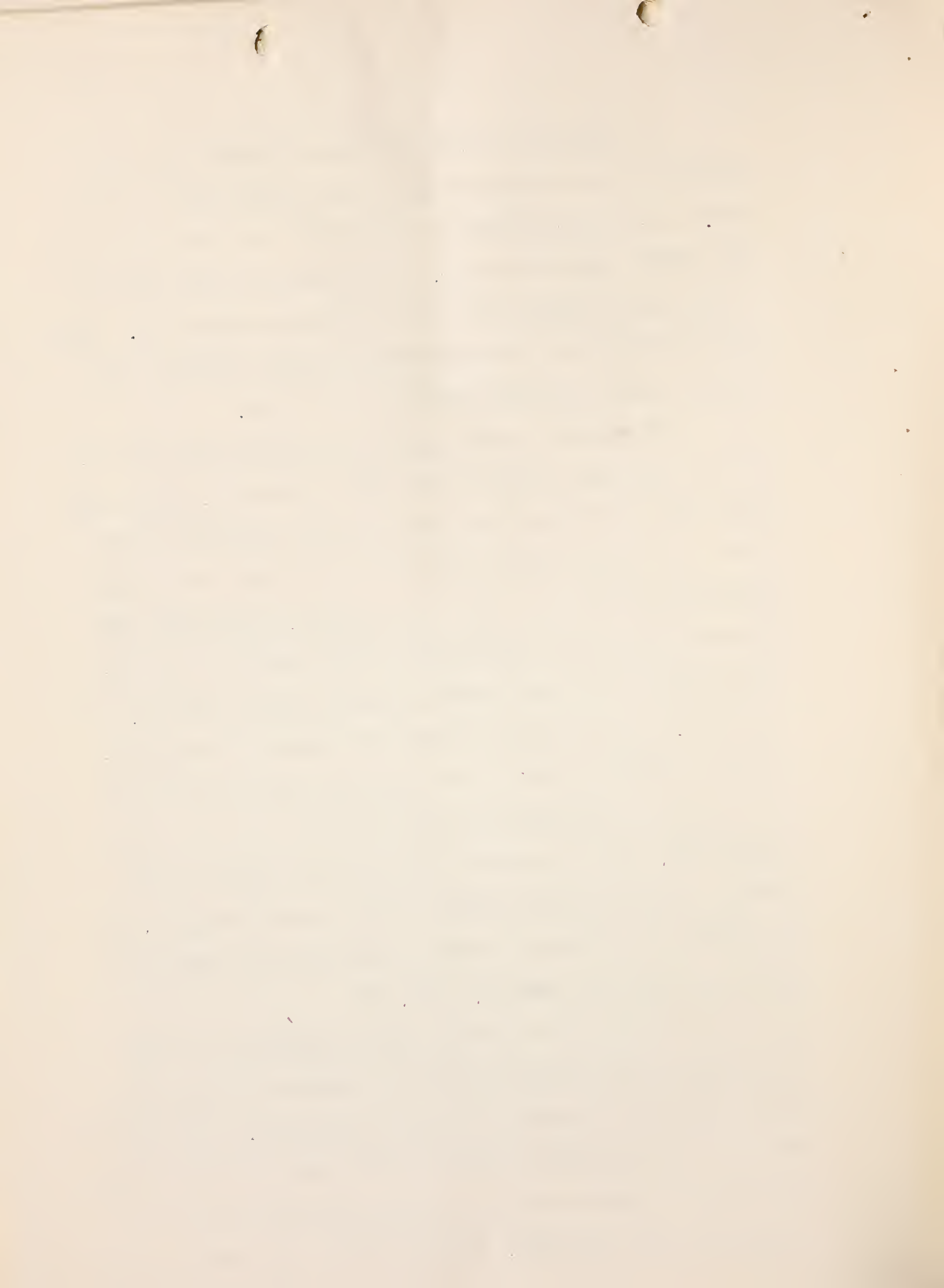


Fig. 1 - Grama-galleta-sagebrush savannah.

The moderately mature and maturely developed soils were occupied by a more or less complete cover of blue grama or galleta grass. Galleta grass generally occupied the less mature soils having a slight degree of salinity. This species was also indigenous to immaturely developed soils with a calcareous surface soil. Blue grama was dominate on the more maturely developed soils or those having a neutral or weakly calcareous surface soil.

Big sagebrush is not confined to any particular soil texture or morphology, but attains its best development on non-saline, loamy, deep, well drained soils which provide available moisture in the soil horizons occupied by its characteristic root pattern. Under varying degrees of temperature, humidity, evaporation, precipitation and seasonal distribution of precipitation, these conditions may be fulfilled by soils varying in texture from sands to clay loams. It has a taproot system which branches widely, penetrating to depths of 5 to 7 feet in maturely developed soils and 10 to 18 feet in the immature, deep, alluvial and coarse textured upland soils. Root occupation of the soil mass conforms rather closely to horizons where moisture is most commonly available. The root system is excellently adapted to absorb moisture both in the shallow and deep soil horizons. (Fig. 2).

Sagebrush invaded grassed areas as individual plants or small clumps around rodent dens or areas otherwise disturbed under virgin conditions in periods of normal precipitation. The landscape presented a grassy expanse spotted with individual sagebrush plants and clumps at varying distances, depending upon the degree of disturbance and soil conditions. (Foreground Fig. 1). Immature soils



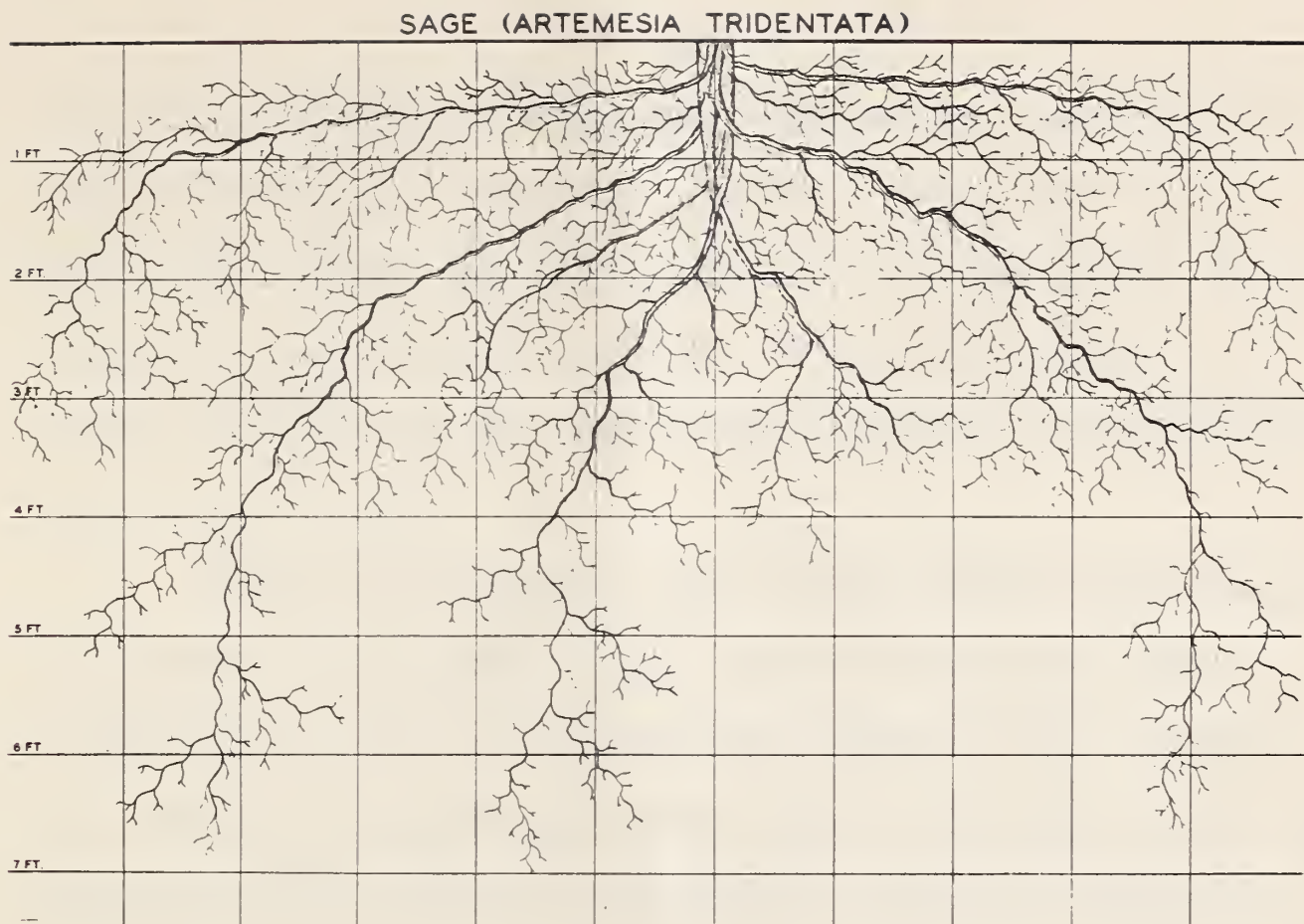


Fig. 2 - Root system of sage (*Artemesia tridentata*).

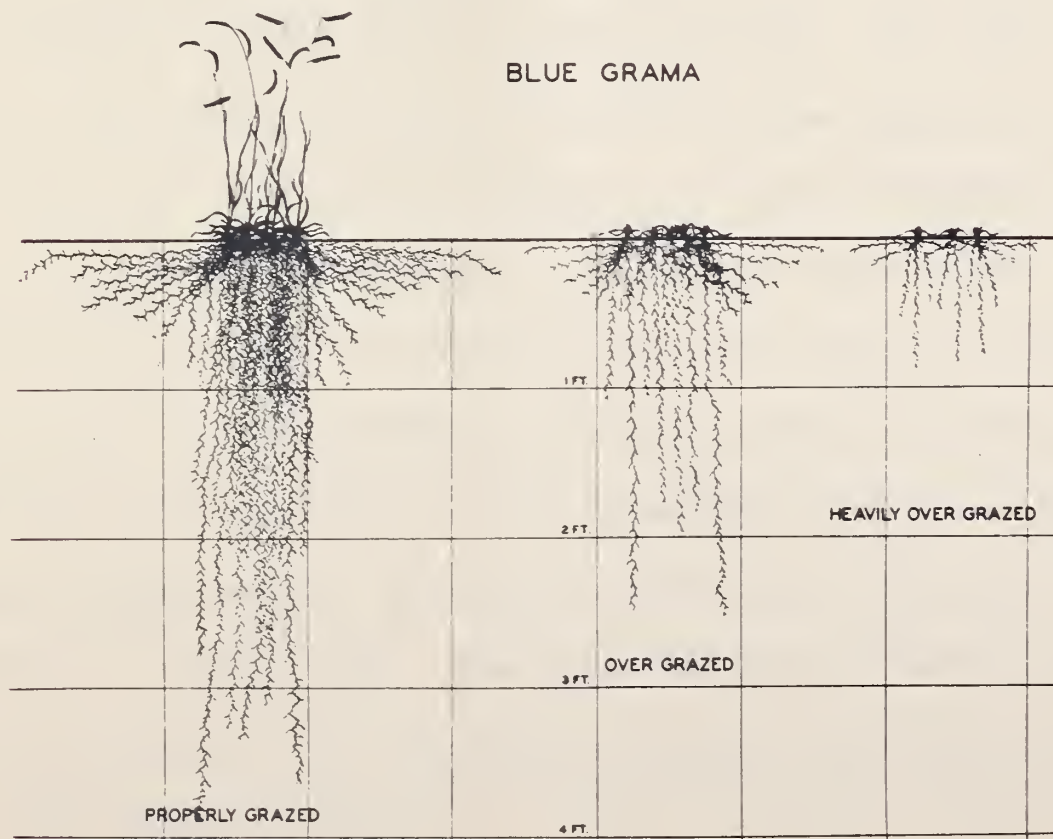


Fig. 3 - Effect of different degrees of utilization upon the root systems of blue grama.



with deep penetration of water were dominated by a sagebrush cover with an understory of sub-climax grasses. (Background Fig. 1). Among other factors, the density and species of the grasses depended upon the degree of soil maturity. Western wheat grass was a common constituent on the more disturbed portions and underdeveloped soils of such areas.

During dry periods the grass areas extended themselves at the expense of the sagebrush (12) because the numerous finely branched grass roots in the surface few inches of soil are much more efficient in absorbing moisture than are sagebrush roots. During periods when excessive precipitation, especially during the dormant season of the grasses, moistened the subsoil the deep rooted sagebrush increased in numbers and vigor.

Blue grama in vigorous condition (Plant to left in Fig. 3) has a general feeding level of about 18 inches. The major portion of its root system, however, is confined to the upper 6 or 8 inches of soil. It is indigenous, therefore, to those locations where the major portion of soil moisture occurs within these limits. Blue grama is very drought resistant and has the ability to remain dormant in what would normally be a growing season if sufficient moisture is not available for the resumption of growth. During prolonged drought periods the deeper penetrating roots absorb enough moisture to sustain life. Blue grama makes its growth in a period of 60 to 70 days after the advent of summer rains, which is usually about the middle of July.

On those areas where blue grama is dominant and grazed in



such a manner as to insure the vigor of the plants it will produce a dense vegetative cover and so completely utilize the factors of the habitat that other species will not be able to invade or compete with it. (Fig. 4).

Galleta (*Hilaria jamesii*) is commonly associated with blue grama and sagebrush in scattered stands on the heavier textured soils which are calcareous in the surface or slightly saline. It is a common constituent of the vegetative cover on shale outcrops and shale derived saline soils.

The strong scaly rootstalks and stems which are very numerous in the surface few inches of soil are more effective in the prevention of erosion than the roots which branch off the rootstalks and extend downward generally from a slightly oblique to a vertical direction. (Fig. 8).

Where the vigor of the plants has not been impaired by heavy overgrazing, the tough, woody rootstalks are sometimes as long as 6 feet. The tough rootstalks constitute its best protection against trampling and overgrazing as well as its most efficient method of reproduction and maintenance of a stand.

With the advent of domestic stock, blue grama and galleta have generally been very heavily overgrazed because of their high palatability. Where the grasses are very heavily overgrazed the plants are so weakened in vigor that the rootstalks do not develop and the stand is restricted to a spotted or bunchlike form. The number and extent of roots have been materially impaired by the constant removal of leaves. An insufficient photosynthetic area



Fig. 4 - Heavy cover of blue grama. Under these conditions blue grama maintains its dominance against all invaders.



Fig. 5 - Sagebrush invading grama grass overgrazed during summer and fall months. Note bunchlike sod and weakened condition of grass.

remains exposed to the sunlight for manufacturing adequate food to maintain the vigor of the plant. Root systems, rhizomes and other plant parts are, therefore, restricted to conform to the lessened food supply. The average condition of blue grama and galleta grass root systems on Southwestern ranges is represented by the central plants in Figs. 3 and 8. Former root occupation of the soil mass is clearly evident in many locations by the relic roots of blue grama and galleta which extend below and beyond the present root systems. These relics show that the former root systems on such areas were similar to the pattern shown by the plants to the left in Figs. 3 and 8.

Under normal conditions of usage where full vigor of grama and galleta plants is maintained it is evident by an examination of the blue grama and galleta root systems as compared to the sagebrush root system (Fig. 2) that sagebrush could not invade blue grama and galleta grass stands or compete with them on an equal basis. The grass roots occupy the soil mass much more completely. The surface soil is especially heavily occupied by finely divided roots which come to within an inch of the surface. It is impossible for a sagebrush seedling to establish itself in a habitat already so completely occupied. Sagebrush can only invade such grasslands where rodents have killed the grass and loosened up the soil, causing deeper water penetration. In the grassland-sagebrush savannahs, as they existed before the advent of domestic grazing, sagebrush would invade such locations during wet seasons but during a dry season the more efficient shallow roots of the grasses intercepted all the moisture, the sagebrush died and grass once more occupied the area.

The restricted root systems and decreased density of overgrazed grama and galleta grass ranges created an ideal condition for the extension of sagebrush into grassland. (Fig. 5). Continued heavy overgrazing, particularly in the summer and fall, has resulted in extension of sagebrush and depletion of the grass until at present sagebrush completely dominates large areas with only rare remnants of grass remaining. Sagebrush has proven relatively ineffective in controlling sheet and gully erosion. The sagebrush clumps tend to concentrate surface water into rills, which upon flowing together soon attain appreciable volume. As a consequence, overgrazed sagebrush areas are subject to extensive sheet erosion and on the more erodible soil are commonly dissected by an intricate system of rills and gullies. Fig. 6 is not an unusual condition found in such areas. A sagebrush cover is not as effective as grass in controlling erosion for the following reasons:

1. The lower density of the sagebrush cover and the more open character of its foliage permits a far greater percentage of the rainfall to fall directly on the soil.
2. The brush clumps concentrate water.
3. Sagebrush roots are not as near the surface as grass roots.
4. Sagebrush roots are not so finely divided as grass roots.
5. Sagebrush roots do not occupy the soil mass as thoroughly as grass roots.
6. Sagebrush roots upon exposure to the air or upon soil being removed to where the roots alternately are dried and wetted, disintegrate rapidly and are not capable of holding soil together.

Sagebrush roots do not occur as near the surface, are not so finely branched and do not occupy the soil mass as thoroughly as galleta and grama grass roots. Sagebrush roots do, however, absorb a major portion of their moisture from the same soil horizons as to galleta and grama grass. It is evident, therefore, that when



Fig. 6 - Former grama-galleta-sagebrush savannah. Overgrazed until sage dominates. Note ineffectiveness of sage to control erosion.

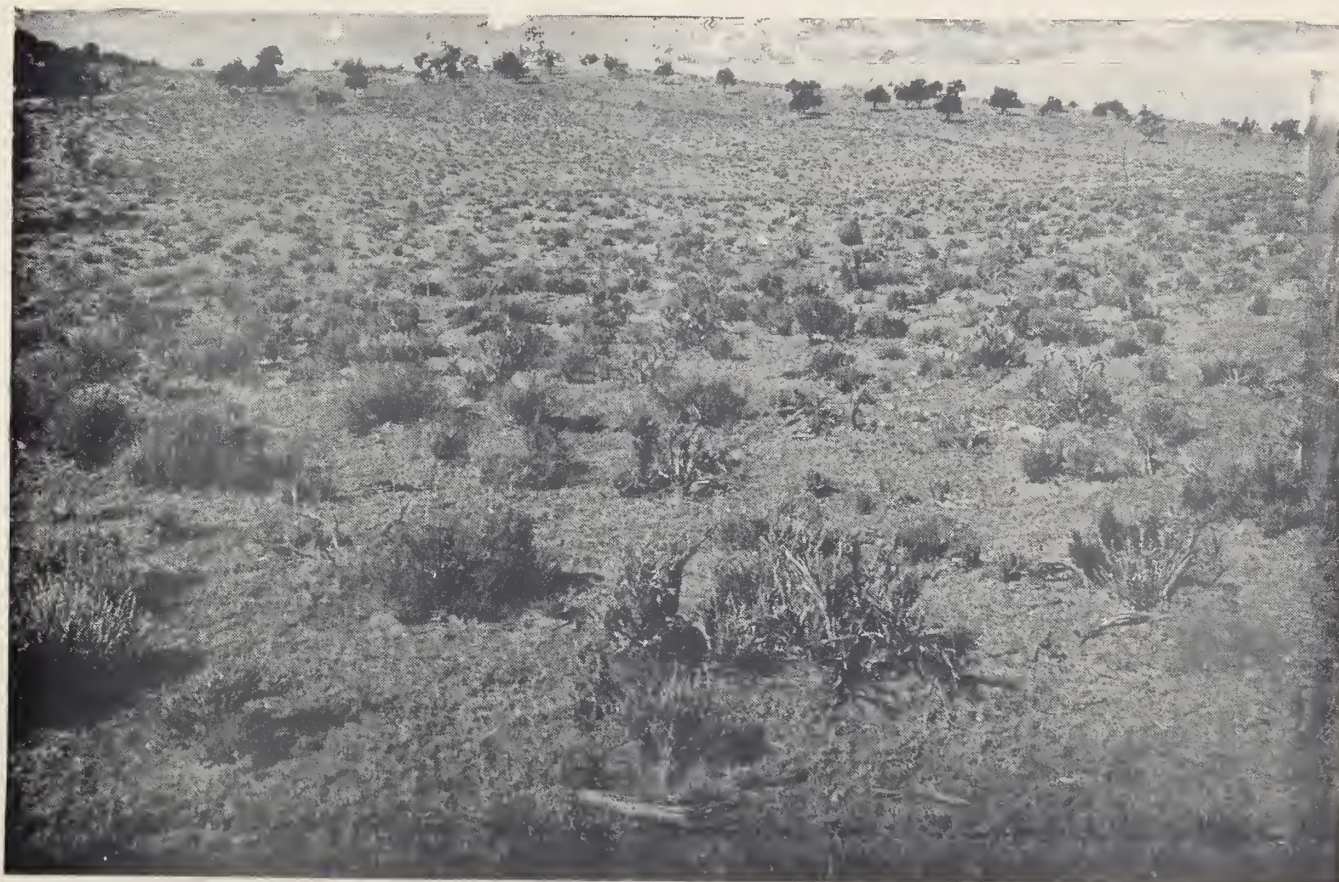


Fig. 7 - Grama sagebrush savannah where the sagebrush is being killed by heavy overgrazing during spring and early summer months.



sagebrush thoroughly occupies a habitat the restoration of a grass cover is slow and difficult unless competition by the sagebrush is materially lessened by grazing or some mechanical means.

SEASONAL GRAZING AS A METHOD OF RESTORING GRASS IN SAGEBRUSH

Seasonal use will bring about wide variations in the botanical composition of the range. Growth may be roughly grouped into three periods: Awakening; intensive or active (zenith); and quiescent or dormant. Different species associated together commonly have these periods occurring at different seasons. The deep rooted browse species commonly make their greatest response to relatively deeply stored winter moisture and the awakening and zenith periods occur during the spring and early summer months. Grama and galleta grass, conversely, do not start or make any appreciable growth until after the summer rains begin in July. Where sagebrush has practically attained its maximum density at the expense of grasses as a result of seasonal overgrazing during the awakening and active growth periods of galleta and grama grass (Fig. 5 and 6), but the grasses still persist in appreciable amounts, the sagebrush may be materially weakened and much of it killed by grazing heavily in the winter, spring and early summer. If the stock are removed early in July for the remainder of the year during the active growth period of the grasses, they will increase in vigor and density. A continuation of such use will eventually result in grass assuming its original dominance, (Fig. 7), providing the grass cover has not been largely destroyed and sheet erosion progressed to the point where the soil will no longer support the

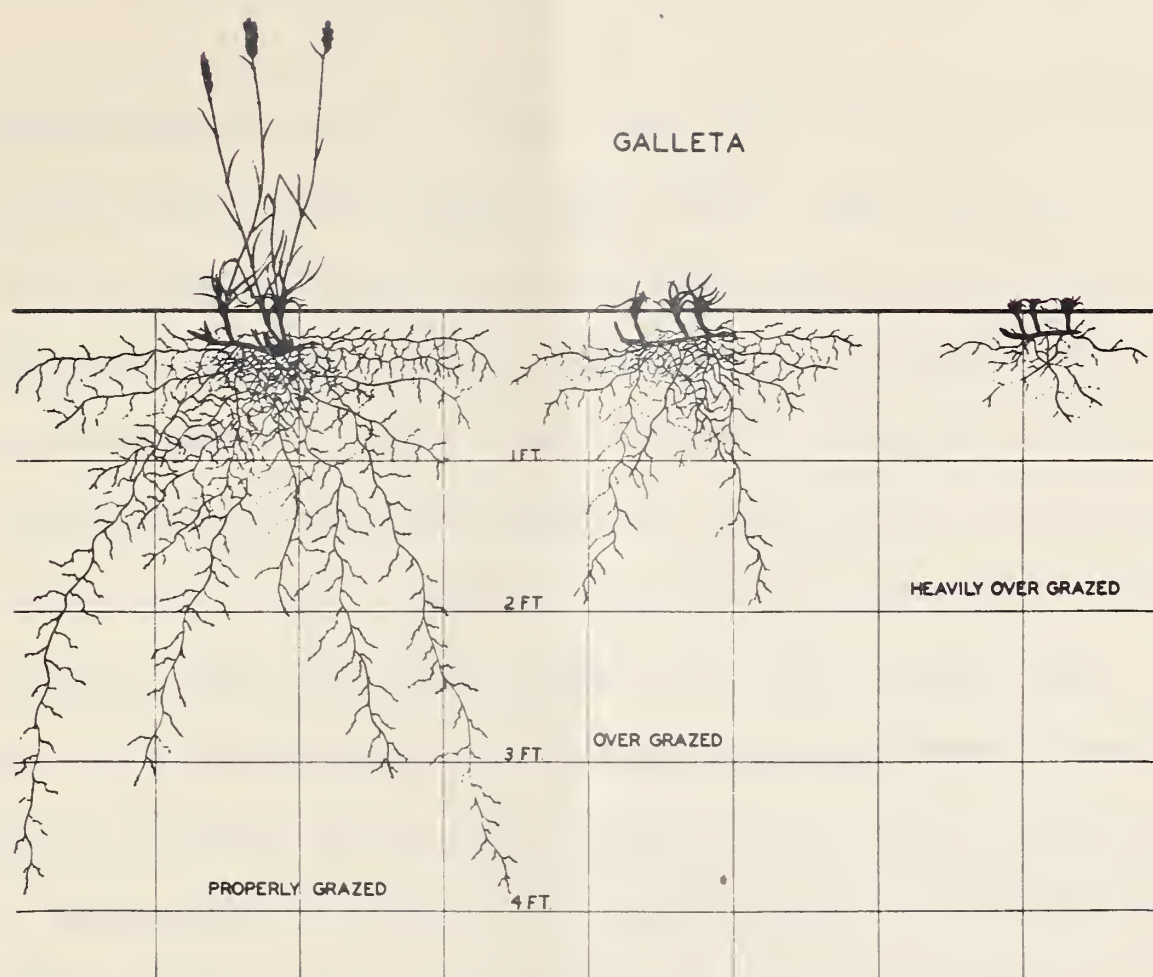


Fig. 8 - Root systems of galletta grass under different degrees of utilization.

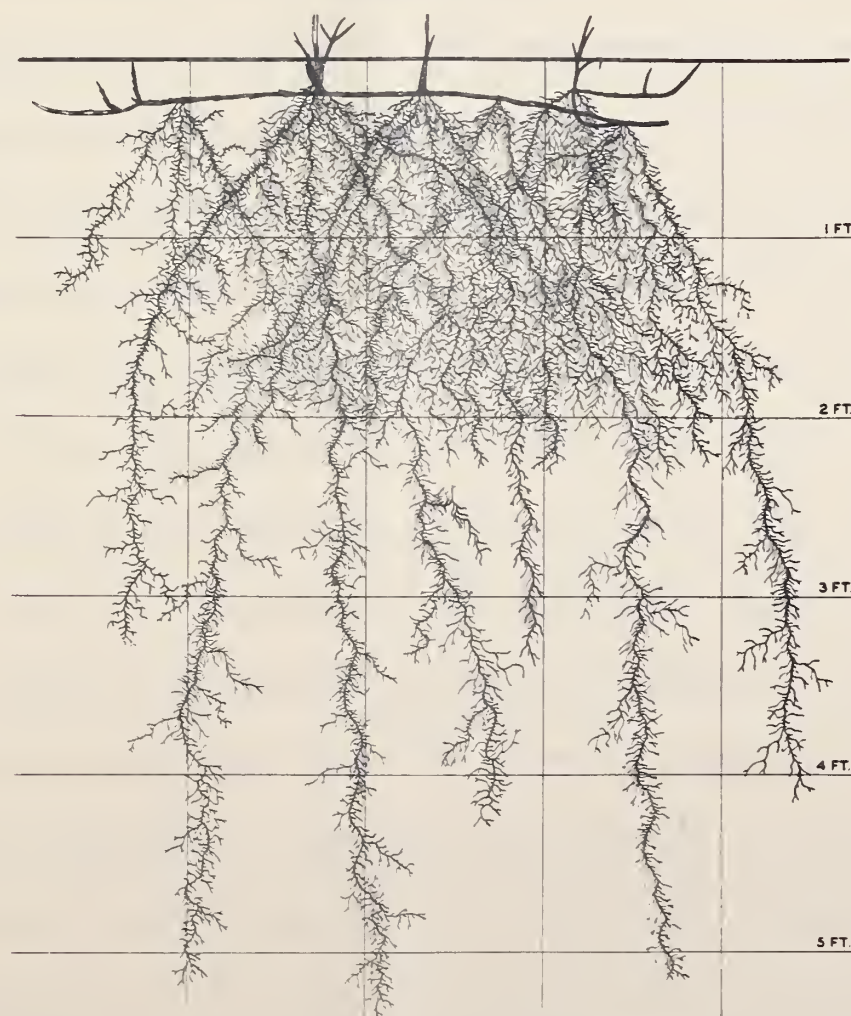


Fig. 9 - Root system of vigorous western wheat grass plant in loam soil.

original grass cover. In such cases, the establishment of a pioneer grass cover (western wheat grass) may be possible. The latter species, however, begins growth early in the spring, in which case grazing should be restricted to the winter months. The establishment of a heavy stand of western wheat grass cannot be secured through weakening sagebrush competition by seasonal grazing as both species make their growth at approximately the same seasons. Since the western wheat grass root systems (Fig. 9) and the sagebrush (Fig. 2) root systems have approximately the same general feeding levels, it is apparent that western wheat grass is handicapped in invading an area thoroughly occupied by sagebrush. Western wheat grass roots, however, do occupy the soil mass more thoroughly than sagebrush roots and are more efficient in the absorption of moisture. The new seedlings or remnants of western wheat grass which are usually present in some degree may consequently be expected to establish a fair grass cover in overgrazed sagebrush areas under restricted usage. (Fig. 10).

Where the sagebrush stand has developed to such an extent that it utilizes all of one or more limiting factors of the habitat, which is usually soil moisture, it is necessary that the vigor of sagebrush plants be weakened if the indigenous grasses are to compete and invade with any marked degree of success. The invading grasses must absorb their moisture from the same soil horizons from which sagebrush is already extracting all available moisture. Grass invasion must necessarily be confined in such cases to those years when there is an excess of moisture not utilized by the sagebrush. The more finely branched and efficient absorptive grass



root systems, however, can sustain the grass once it is established and increase its density during favorable seasons until a rather complete understory of grass has been established. When this condition is attained the grass will begin to offer serious competition to sagebrush in dry seasons by intercepting the shallow penetrating moisture before it reaches sagebrush roots. This process must extend through several rainfall cycles and only partial recovery can be expected within the time limit of one individual's range operations unless sagebrush is artificially removed.

BURNING

Burning as a means of killing sagebrush and giving grass an additional advantage has been very effective when the area burned has been very conservatively grazed until the grass has developed a good stand. (Fig. 11). General recommendation of the practice cannot be made, however, as burning so denudes the surface that accelerated wind and water erosion follows as a natural course unless very rigid restriction of grazing is practiced until a protective cover of perennial grass is established. The stimulation to growth of palatable weeds and the grass remnants as a result of the burning and removal of sagebrush competition, together with the removal of physical obstruction by the brush to the movement of stock offers a temptation to graze such areas that stockmen rarely resist. Stockmen who have properly grazed burned sagebrush areas until a protective cover of perennial grasses has become established have estimated a three to ten-fold increase in carrying capacity.



Fig. 10 - Vegetative cover and gully (indicated by darts) on this five per cent slope were similar to that shown in Fig. 6 in 1930. Recovery and stabilization achieved by moderate winter grazing only. No sagebrush seedlings are present and occasional old shrubs are dead.



Fig. 11 - Area to the right, sagebrush burned off in 1929. Conservatively grazed in the winter only since burning. Carrying capacity increased threefold.



RAILING OR DRAGGING

Some excellent results have been obtained by the use of drags made of railroad rails in sagebrush control (Fig. 12). This method of control can be recommended for more general use than any other because it is cheap, involves the use of no expensive equipment, and does not accelerate wind and water erosion if grazing is not carefully restricted, as may occur under other methods of treatment. Once across with a rail drag will not effectively break off sagebrush. It is necessary, therefore, to rail sagebrush a second time in the opposite direction. The area shown in Fig. 12 was railed in this manner in 1929. Two years previous to railing and since the treatment, grazing has only been allowed during the dormant season of the western wheat grass. There are no sagebrush seedlings, but competition of the western wheat grass has not noticeably weakened the remaining sagebrush. Sufficient sagebrush remains after this treatment to carry stock through periods when the grass is covered by deep snow, to prevent drifting of snow, and to provide a desirable grass browse grazing ratio.

The brush broken off and left upon the surface (Fig. 13) checks the flow of water, facilitates water penetration, shades the soil, aids seed germination, and protects young grass from too close grazing.

When care is exercised to drag on the contour a large portion of the brush will be deposited in the rills and washes, aiding materially in their stabilization and the spreading of

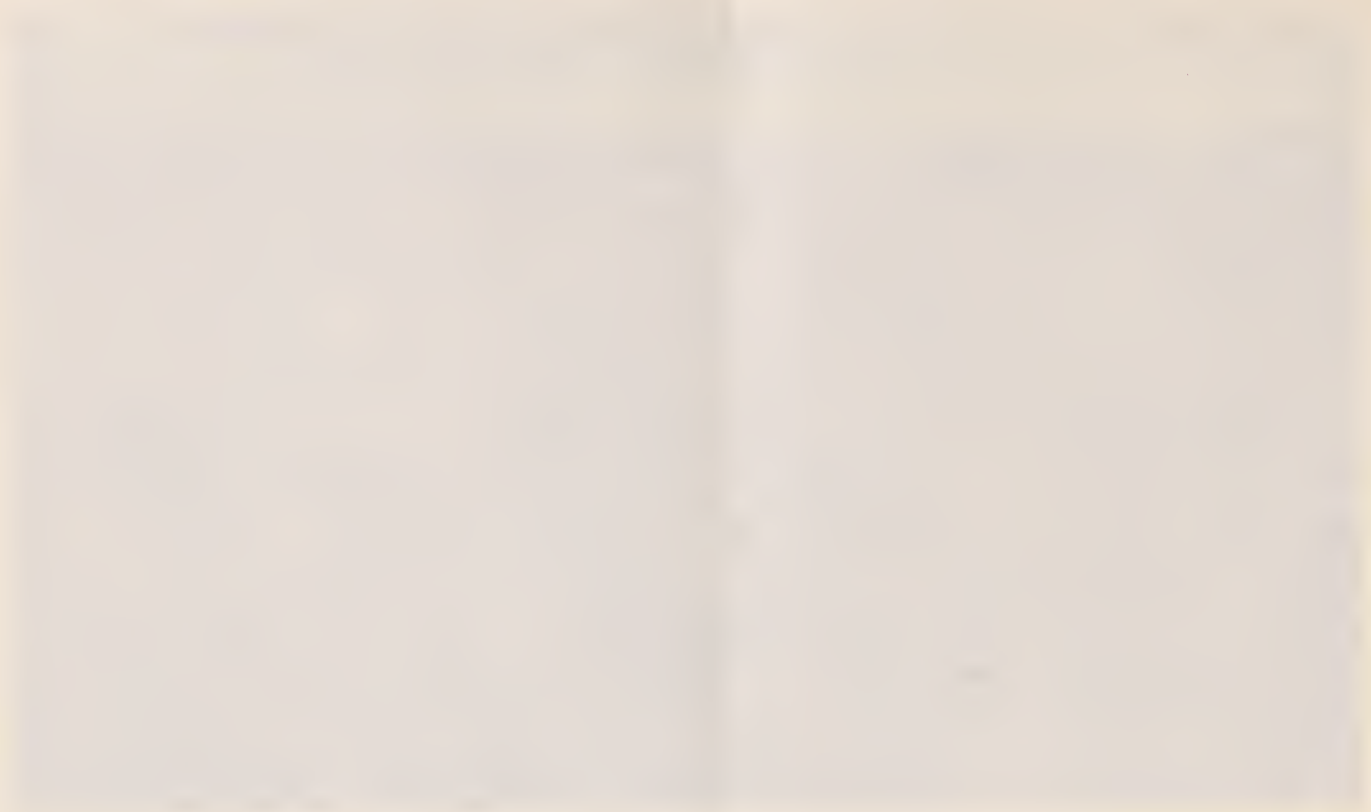




Fig. 12 - Sagebrush railed in 1929. Note the heavy grass cover.



Fig. 13 - Close-up of Fig. 12. Note the debris left on the ground surface as a result of this treatment.



water. Sagebrush of different sizes, maturity and density cannot be equally well controlled by riling. Riling will also be more effective on some soil types than others. The farmer will need to resort to some trial and error attempts with the weight of the drag, pitch at which cutting edge of the rail will operate, and also condition of the soil when best results can be obtained.

WHEATLAND DISK

The wheatland disk is sometimes used as a means of sagebrush control but its use is not recommended. Only the older and more brittle brush is broken off. (Fig. 14). The quantity of debris left on the surface is very desirable but it is not dragged into washes and rills as in riling. Since the stems of young sagebrush plants are seldom broken off growth is only temporarily checked and the density is but very slightly decreased. This method should not be employed where remnants of galleta and grama grass occur as they will probably be torn out of the ground.

RIPPER OR CUTTING DRAG

A Killifer ripper or an A-shaped drag with cutting blades which may be adjusted to run at a uniform desired depth under the surface may be effectively used to destroy sagebrush. The original cost of these implements is rather high and more power is necessary to operate them than other implements. These methods should not be employed where any grass other than western wheat grass is present as the soil is very thoroughly stirred to varying depths. Western wheat grass is stimulated rather than harmed by such treatment as its chief method of spreading is the underground rootstalks which occur in depths between 2 and 8 inches. The cutter and ripper



Fig. 14 - Sagebrush clearing one year after treatment with a wheat-land disk. This area had been lightly grazed for about 10 years during the dormant season only, and western wheat had obtained a foothold. Due to sagebrush competition, however, the grass was unable to attain appreciable density.



Fig. 15 - A sagebrush area treated by cutting blade drag on 30-foot contour strips. Water diverted by earth dikes, brush piled in percolators and cleared strip seeded to grass.

blades will cut the rootstalks into pieces and scatter them through the soil, thus aiding in distribution of the grass and thickening the stand. No appreciable quantity of rootstalks will be exposed to the air and killed.

In sagebrush where artificial re-seeding is necessary to re-establish a grass stand, the ripper and cutting drag are very effective in preparing a good seed bed. Broadcasting is the only method of seeding that can be employed because of the debris left upon the surface. Success in artificial revegetation with this method is uncertain, but drilling is not possible because of the litter of brush left upon the surface.

A plan of clearing sagebrush, diverting and spreading water and re-seeding which promises to be very successful, is as follows: Strips 30 feet wide on the contour are cleared of sagebrush by whatever method is best suited to conditions. 1 - Clear areas with no grass, or wheat grass only, with ripper or cutting drag. 2 - Areas with a fair to good stand of sod grasses may be cleared by railing or with grubbing hoes. Collect the brush into a percolator or spreader. The purpose of this is to spread water, check sheet erosion and detain water long enough to obtain sufficient soil moisture to insure the establishment of a grass cover and large volume growth of grass. Trials have indicated that the proper place to locate the percolator is $1/3$ of the distance down the slope from the upslope side of the cleared strip. This location is believed best because added soil moisture resulting from the action of the percolator extends farther down than up the



slope. Sagebrush is well adapted to construction of percolators. Effective percolators can be made of sagebrush without wire, rock, stakes or other materials necessary with some types of brush to anchor the percolator in place. Brush should be laid with the tops upslope. If a heavy flow of water is to be handled the base of the spreader should be widened by laying interlocking rows of brush on the surface until the proper width is attained. Always place the brush parallel to each other with tops extending upslope. Spreaders 2 feet in height constructed in this manner have been over-topped by diverted water, but with no displacement of the brush. (Fig. 15).

Water diverted by the earth dike No. 1 in Fig. 15 overflowed portions of the spreader for a distance of 200 feet from the diversion three days before the photograph was taken. Note the uniform percolation, absence of rills, and stability of the brush percolator.

In the field shown in Fig. 15, contour strips 30 feet wide were cleared by a cutting drag, leaving strips 20 feet wide in sagebrush. The sagebrush strips were not uniform in width as irregularities in slope were provided for here in order that the cleared strips could be uniform in width throughout their length.

The cleared strip was drilled to grass. Earth diversions 1 and 2 in Fig. 15 were placed in washes to divert water into the brush percolators and spread it over the area. Three days before the photograph was taken .94 inches of rain fell in $1\frac{1}{2}$ hours, followed by several lighter showers. Between 60 and 80 acres of untreated sagebrush on a 5 per cent slope and a clay loam soil lay

outside and above the treated area as shown in the background of Fig. 15. The two earth diversions shown and one immediately below with the accompanying brush percolators diverted, spread and put into the soil a quantity of water which was in places a foot deep above the first percolator and which over-topped it occasionally for a distance of 200 feet from the end of the diversion. Diverted water extended a total distance of 300 feet along the percolator from the diversion. The percolator was not displaced and water was uniformly spread without cutting. Tests made at this time for depth of water penetration at a distance from the influence of water diverted from gullies showed wet soil 24 inches deep for a distance of 6 feet above and 12 feet below the percolator, and only 4 inches deep in the uncleared strips. Above and below the influence of the percolators, penetration in the cleared area due to soil disturbance was about 12 inches.

A heavy road grader and also a caterpillar tractor equipped with "bulldozer" trail builder attachment have been effectively used in clearing sagebrush, leaving the brush in windrows which make fairly effective percolators. When these implements are used on the contour, brush and soil are dragged along and deposited in the rills and washes quite effectively filling all but the deeper ones. This operation leaves the soil surface in good condition for seeding with a grain drill. Between 50 and 60 per cent of the surface can be cleared in this manner at a cost of \$1.00 per acre.

BUNCH GRASS - SAGEBRUSH SAVANNAH

Sagebrush has associated with it, in areas having over 18 inches annual precipitation, varying proportions of tall grasses. Originally the proportion of grass which constituted the total vegetative cover was determined by soil and water relationships. Agropyron spicatum dominated the more xeric locations on the steeper slopes, southern exposures, and shallower soils. Elymus condensatus dominated the more mesic swales, northern exposures and deeper soils. The two species were associated together in more or less equal proportions in intermediate locations. Numerous other tall grasses of lesser importance were associated with the two major dominants. Sagebrush played a very minor role, being restricted to disturbed, stony, and immature soils. Over most of its area the bunch grasses have been replaced either by sagebrush which owes its advantage to overgrazing or by the annual vegetative cover of downy chess, which owes its advantage to overgrazing, plus burning. Sagebrush is now so abundant that the major portion of this region has been assigned to the sagebrush climax, but the study of relict and protected areas proves that grasses are climax and will again assume dominance when grazing is reduced or eliminated.

Many rough and inaccessible portions of fields on which wheat is grown have not been broken. The cultivated fields were very heavily overgrazed and were converted to almost pure sagebrush before they were broken. As the unbroken portions of fields can only be grazed after wheat is harvested the grass remnants have had an opportunity to grow and spread undisturbed during the growing and seeding period. In many locations where such use has been light and



Fig. 16 - Sagebrush area being reclaimed by *Agropyron spicatum*.
Moderately grazed in winter only.



Fig. 17 - Sagebrush area being reclaimed by *Elymus condensatus*.
Moderately grazed in winter months only.

extended over a period of 10 to 20 years the grass has again assumed dominance, killing the sagebrush.

Figure 16 shows a corner of a wheat field too rough to be broken which has been only moderately used during the winter for 16 years. Note the dead sagebrush and thick stand of Agropyron spicatum.

Figure 17 shows another portion of the same field where Elymus condensatus has killed the sagebrush. The soil is deeper here and receives some run-off.

In this habitat grasses can ultimately overcome sagebrush with proper grazing during the winter months without weakening the sagebrush by artificial means. Elymus condensatus has a root system extending to 9 feet in depth. The roots occupy the soil mass very thoroughly with a general feeding level around 6 feet. This pattern of root system offers active competition throughout the active feeding zone of sagebrush roots. Agropyron spicatum roots penetrate to 6 and 7 feet with the general feeding level between 4 and 5 feet. Where sagebrush occurs in the shallower soils the roots are shorter and here also they must actively compete for moisture in the same soil zones with the much more numerous and finely branched grass roots.

On some of the worst depleted ranges where grasses are still present in restricted amounts, or where artificial re-seeding is necessary, recovery will be materially hastened by weakening sagebrush plants in order that competition with the grasses will be less active. Grazing should in every case be on a carrying capacity basis and if possible limited to the dormant season of grasses. If impossible, rotation grazing will aid the grasses in becoming re-established.

